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PATENT SPECIFICATION

Convention Date (Germany): Oct. 21, 1937.

511,661

Application Date (in United Kingdom): Oct. 21, 1938. No. 30511/38.

Complete Specification Accepted: Aug. 22, 1939.

COMPLETE SPECIFICATION

Improvements in and relating to Springs for Vehicles

I, HERMANN KAPPER, a German citizen, of Friedrichstr. 1, Berlin-Südende, Germany, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

When a vehicle provided with springs, passes over a certain obstacle at a certain speed, the force of the jerk or shock caused by the obstacle is proportional to the weight of the mass supported by the springs. If for instance the weight of the empty vehicle is only the fourth part of that of the vehicle with a full load, the shock caused by the obstacle with no load has only the fourth part of the strength of the shock at full load. Since the usual springs have a linear characteristic, Fig. 1, I, so that within their entire working field equal shock forces will cause equal deflections of the spring, the shock P_v occurring at full load will cause a deflection f_v proportional to P_v, whilst the shock P_1 at no load will cause a deflection f_1 proportional to P_1, which deflection is to f_v as P_1 to P_v, and therefore is smaller relatively to the shock forces.

The ideal requirement for a spring is that the deflections occurring under different loads are always unalterably alike, so that at any given velocity an obstacle encountered under full load will cause the same deflection of the spring as under no load.

Mathematically formulated this leads to the condition that the characteristic of such a spring is a curve, Fig. 1, II, at which tan α, i.e. the differential coefficient, is equal to $\frac{c}{P}$, so that the stroke f of the spring is equal to $c \log P$. On the basis of the same total stroke of the spring, the spring will within the range of higher loads be relatively harder than a spring of linear characteristic, and within the range of smaller loads it will be correspondingly softer.

The recognition that it is advantageous in spring suspension for motor vehicles to use instead of springs with linear characteristic springs with progressive characteristic is not new.

So are for instance progressive spring arrangements known, in which the load over one or more cranks acts upon a common spring, for instance a cylindrical helical spring. This construction is however much more complicated than a normal spring arrangement, in which the spring is located between the wheel and the load. Moreover, as can be seen from the curve III in Fig. 1 it only partially fulfils the above named ideal requirement.

It has also been proposed in cylindrical helical springs to reduce the cross-section of the wire or rod from which the spring is made over a part of the same, whilst maintaining the same form of the cross-section as in the other parts of the wire. Such a spring has a characteristic formed by two straight lines of different slopes, joined by a short bridge. This spring does not fulfil the requirement for equality of the deflection under the shock.

On the other hand springs in the form of truncated cones and serving as buffer springs are known, the turns of which, when the spring is loaded, settle on the bottom one after another. The characteristic of such a spring is indicated by the curve IV in Fig. 1. This spring has the disadvantage that within the range of full load the amount of compression caused by shocks is extremely small and within the range of light load very large. The behaviour of these springs is thus contrary to that of springs with a linear characteristic and the former can therefore just as little as the latter be used for obtaining equal shock strokes.

The invention solves in two ways the problem of providing springs with the same shock resilience under all loads.

According to one way use is made of the fact that the characteristics of a common buffer spring, Fig. 8 and 9, I, and of a spring with linear characteristic, Fig. 8 and 9, II, when the load is distributed according to a definite ratio on both springs, unite themselves to a total characteristic, Fig. 8 and 9, III, which deviates only very little from the logarithmic characteristic. In this embodiment the springs are arranged

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either parallelly, Fig. 8, or in series, Fig. 9.

According to the other way use is made of wound torsion springs, with coils which settle one after another, and the cross-sections, turn radius and pitch are so dimensioned that the desired characteristic is obtained.

This embodiment of the invention is thus based on the fact that with a coiled spring with windings settling one after another it is possible to obtain the desired characteristic by dimensioning at least one measure of the spring (cross-section, radius, or pitch) according to the requirements which the desired characteristic has to fulfil.

This can, with cylindrical helical springs, be achieved by a corresponding non-uniform dimensioning of the convolutions of the spring when winding it, whereby a final stress per winding decreasing with the spring stroke per winding and coincidently an unfavourable utilization of the material, must be taken into account.

This can be avoided by altering the pitch and the cross-section of the cylindrical helical spring progressively after a certain principle.

Also with conical springs the desired characteristic can be achieved by altering the pitch per winding.

Coiled springs of the desired characteristic can also be obtained by starting from a circular winding and at the same minimum diameter gradually increasing the longitudinal diameter, so that the individual windings, commencing with the hardest one, gradually run more straightly (Wedge springs).

It is also possible to use a structure in which normal springs (with linear characteristic) guide the wheels and absorb lateral shocks, but only take up a small part of the load, whilst the main load is received by a spring according to the invention.

I am aware that logarithmic coiled springs are known for effecting oscillation-free suspension of instruments.

Some embodiments of the invention are illustrated by way of example in the accompanying drawings, in which:—

Fig. 1 shows the curves of various springs.

Fig. 2 shows a cylindrical helical spring formed of metal of circular cross-section.

Fig. 3 shows a cylindrical helical spring formed of metal of rectangular cross-section of varying width.

Fig. 4 shows a cylindrical helical spring formed from a plurality of strips of different lengths.

Fig. 5 shows a cylindrical helical spring consisting of two parts arranged with the convolutions of one interspaced with those of the other.

Fig. 6 shows a spring which as seen from the side is of wedge like form.

Fig. 7 is a plan of the same spring.

Fig. 8 shows curves of parallely arranged springs which complement each other.

Fig. 9 shows curves of spring which complement each other and are arranged in series.

Fig. 10 shows a spring-suspended vehicle axle.

Fig. 11 is a front view of a spring-suspended rocking lever.

Fig. 12 is a lateral view of the same rocking lever.

Fig. 13 is a lateral view of a set of double wheels with spring-suspended rocking levers.

In Fig. 1 the curve II shows the characteristic at which the resilience f is the same for all loads. This condition is as shown above fulfilled by the curve $F = c \log P$. The spring must respond to it between P_1 as no-load, and the maximum load whilst its behaviour at loads less than P_1 is of no consequence. One therefore lays a tangent to the curve at P_1 and so obtains the part of the curve between zero and P_1, that is to say before the weakest winding settles, which then possesses a linear characteristic. The spring suspension according to the invention is to be dimensioned substantially after the curve II, which shows the part from P_1 upward.

Fig. 2 shows a cylindrical spring formed of metal of uniform circular cross-section with different distances between adjacent convolutions, which distances are so selected that after the settling of the weakest convolutions the further course of the characteristic follows the curve II in Fig. 1. By this means the stress at the settling of each convolution is proportional to the original winding distance, or pitch, so that the stress on the spring is lower and the weight of the same is larger than that of a spring which is fully loaded in all windings.

The cylindrical spring shown in Fig. 3 is made from a flat rod, the width H of which changes in accordance with the requirements of the desired characteristic. The distance or pitch between the convolutions may in consequence generally be uniform since, under equal stress, the deflection of a convolution is only dependent on the depth B of the cross-section, which always remains the same and is smaller than the dimension H.

The relation between the largest and the smallest dimension H is first of all

dependent upon the relation of the forces between which the spring characteristic is to follow the logarithmic curve. If one hereby reduces the dimension H internally whilst maintaining the original external diameter, the radius R will increase with decreasing H, whereby part of the reduction of the same is saved.

Fig. 4 shows the same spring as Fig. 3 but instead of the variable dimension H a plurality of superimposed springs with the unvariable dimension H_1 is used. Only one of the springs has the full length, whilst the others become gradually shorter. The free ends of the outermost springs are bevelled, in order to avoid sudden jerk-like alterations of the load. The disadvantages of this arrangement are that it is composed of numerous parts and that, as equal stresses demand equal spaces between the windings, the pitch of the individual springs must be varied, which renders the manufacture difficult.

This will be better understood on reference to Fig. 4 where it will be seen that the pitch of a convolution varies with the number of springs it contains. The first convolution, starting from the top, comprises one spring, the second, two, and so on. Therefore the thickness of the second convolution is double that of the first, and that of the third twice that of the first, and so on. Now, to get the spaces between the convolutions, that is from the bottom of the upper winding to the top of the lower—equal to each other, the pitch of the windings of the individual springs must vary from convolution to convolution of the spring as a whole, in proportion to the number of springs contained in each of said convolutions.

The same is the case if the flat material shown in Fig. 3 is placed edge-wise. If however the required characteristic leads to springs the dimension H of which increases uniformly, two like interwound springs *c*, *d*, Fig. 5 may be used, which then can have the same pitch.

For springs of circular and rectangular cross-section with a winding radius varying after any principle the logarithmic characteristic will lead to dimensions, which are not well suited for use in practice, because the length of the winding of the hard spring part of small diameter will become large in comparison with the length of the soft spring part.

Good results can be achieved with the spring according to Figs. 6 and 7. The same is made from a wire of circular cross-section and is initially wound cylindrically with the radius R and thereupon substantially rectangularly with semi-circular ends with the same radius R. The length of the rectangles depends upon the loads and the distance between the convolutions upon the deflections, which latter, when varying end stresses are allowed, may be the same for all windings. The advantages of this spring lie in the use of a wire of circular unvarying cross-section and, result in a better utilization of the material than in the cylindrical spring, Fig. 2.

With conical, buffer and wedge-shaped springs the stroke of each convolution can be altered also by adequate profilation of the ground plate (base) on which the windings settle.

If a spring according to the invention bears only part of the total load, the characteristic of it is so chosen that it and the characteristic of the spring which takes up the rest of the load complement themselves substantially to the logarithmic curve.

For the other solution of the problem of the invention in accordance with the diagrams of Figs. 8 and 9 there are two possibilities, namely the parallel arrangement of both springs, Figs. 9—11, and the arrangement of the same in series (shown in Fig. 13).

For a parallel arrangement the common buffer spring offers a good possibility. With a uniform cross-section the deflection of it is the same for all windings, and the winding radius alters uniformly, so that the manufacture is particularly simple.

The characteristic, Fig. 8, I, of this spring runs lineally until the abscissa is zero. At this abscissa the first convolution settles, and for the remaining spring stroke the characteristic is curved. The characteristic II of the normal spring of the same spring stroke is linear. The sum of the abscissae of both characteristics, i.e. the sum of the forces, gives the total characteristic IV, which deviates only little from the logarithmic curve III.

When such a common buffer spring and a normal spring are arranged in series the total characteristic will also lie close to the logarithmic curve. The curve I shows the characteristic of the buffer spring, which crosses the abscissa axis at P_1 and during one half of the spring stroke ascends in the form of a curve. The linear characteristic II of the complementary spring extends between the same points. The sum of their ordinates, i.e. of the spring strokes, gives the total characteristic III, which deviates so little from the logarithmic curve that the deviations cannot be shown in the drawing.

The complementary spring arranged parallelly to the support spring may con-

sist of two springs of linear and curved characteristic, arranged behind one another. Also the complementary spring which is arranged in series to the support spring may consist of two parallel springs of linear and curved characteristic.

In spring arrangements with rocking levers, Figs. 11—13 the lever arm A alters with the resilience, so that the characteristic of the total resilience will not be linear, even if the support spring has a straight characteristic itself. Also this characteristic can according to the invention be made logarithmical or substantially logarithmical by means of springs of freely selectable characteristic, Figs. 2—7, and also by complementary springs, such as for instance common buffer springs.

Figs. 10—13 show some examples of the utilization of the invention in practice.

Fig. 10 shows the spring suspension of an axle *f* of a freight automobile or a trailer, in which the normal leaf spring *g* is attached to the frame *h* in a manner known *per se* and carries about half of the load. Parallel to the spring *g*, between the frame and the axle, a common buffer spring *i*, which carries the other part of the load and is so dimensioned that the total characteristic is of logarithmical form.

Figs. 11—12 show a vehicle with rocking levers *k*, which are attached to torsion springs *l*, which are resistant to bending stresses. These springs have a linear characteristic *per se*, but due to the lever arms A the characteristic of the vehicle becomes degressive, i.e. the shock resilience increases still faster at increasing load than at linear characteristic. The wound torsion springs *m* are parallel to the springs *l* and so dimensioned that the total characteristic becomes logarithmical or substantially logarithmical. On each rocking lever two springs *m* are arranged, the ends of which are attached to the frame or vehicle body *h* and to projections *n* on the levers *k*, respectively.

In Fig. 13 the two rocking levers *o* of the rear wheels, for instance of a six-wheel vehicle, swing about a common axis *p*. The levers *o* are formed with arms *q*, between which a spring *r* is arranged, which due to the successively increased spacing or pitch of its convolutions has a logarithmical characteristic.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. A progressively acting spring arrangement for vehicles, more particularly for motor vehicles and trailers, with wound coiled springs, the windings of which settle one after another at increasing load, characterised in that the said springs, alone or in combination with known springs, as to cross-section, pitch per winding or radius per winding or as to a plurality of these values are so dimensioned that the total characteristic of the spring arrangement lies near to the logarithmic curve.

2. Spring arrangement according to Claim 1, with cylindrical coiled springs of unvariable cross-section, characterised in that the distance between the individual windings is so dimensioned that the characteristic of the springs, from the settling of the first winding, follows or nearly follows the logarithmic curve.

3. Spring arrangement according to Claim 1, with cylindrical coiled springs of rectangular cross-section and equidistant windings, characterised in that the length or the width of the cross-section varies in such a manner that the characteristic of the springs exactly or nearly follows the logarithmic curve.

4. Spring arrangement according to Claim 3, characterised in that the side of the cross-section perpendicular to the axis of the spring alters and the external diameter remains constant.

5. Spring arrangement according to Claim 3, characterised in this that the side of the cross-section perpendicular to the axis of the spring is subdivided in superimposed strips of equal widths and different lengths.

6. Spring arrangement according to Claim 3, characterised in this that the side of the cross-section parallel to the axis of the spring alters continuously and that two springs of that kind with like pitch are interwound.

7. Spring arrangement according to Claim 1, characterised in this that the windings of the coiled springs are limited by half-circles (180°) of unvariable radius and continue substantially rectangularly, whereby the longitudinal axes change in such a manner that the characteristic of the spring, after the first winding has settled, exactly or nearly follows the logarithmic curve.

8. Spring arrangement according to Claim 1, characterised in this that in parallel with a normal support spring, one or more wound coiled springs are provided which are of such dimensions that the total characteristic of the arrangement follows or nearly follows the logarithmic curve.

9. Spring arrangement according to Claim 1, characterised in this that instead of or in series with a normal support spring one or several springs are arranged,

which are of such dimensions that the total characteristic of the arrangement follows or nearly follows the logarithmic curve.

Dated this 21st day of October, 1938.
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Bath House,
57—60, Holborn Viaduct, London, E.C.1,
and at
34, Dame Street, Dublin, Ireland,
Agents for the Applicant.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1

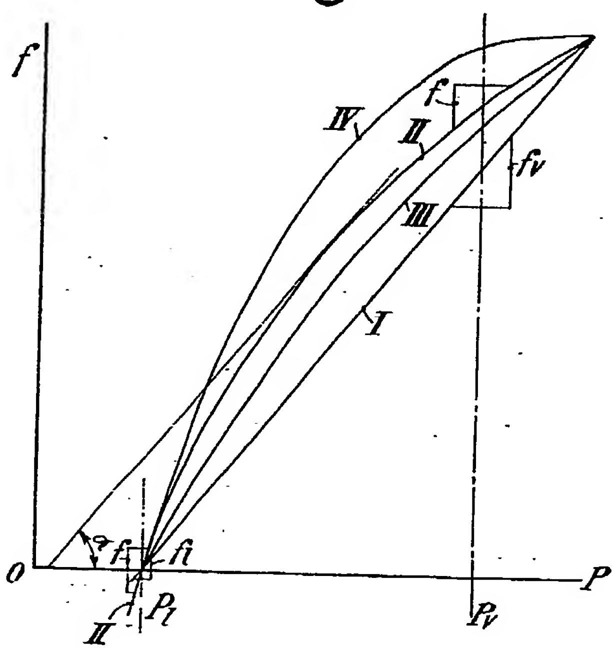


Fig. 2

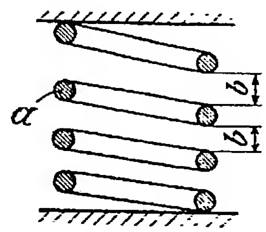


Fig. 3

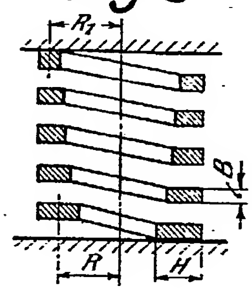


Fig. 4

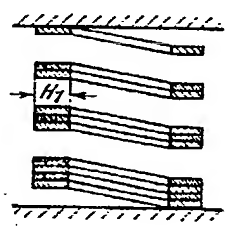


Fig. 5

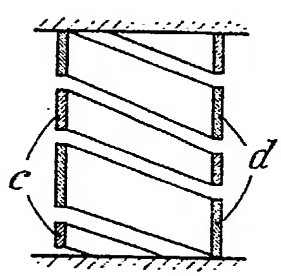


Fig. 6

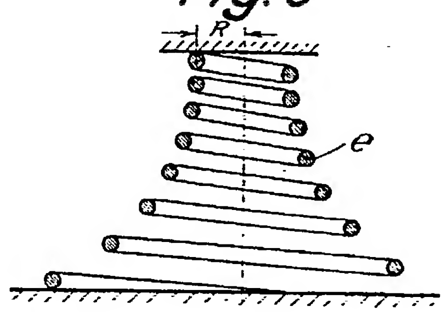


Fig. 7

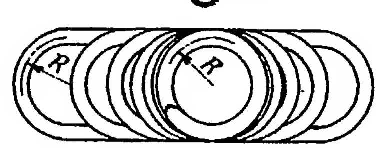


Fig.8

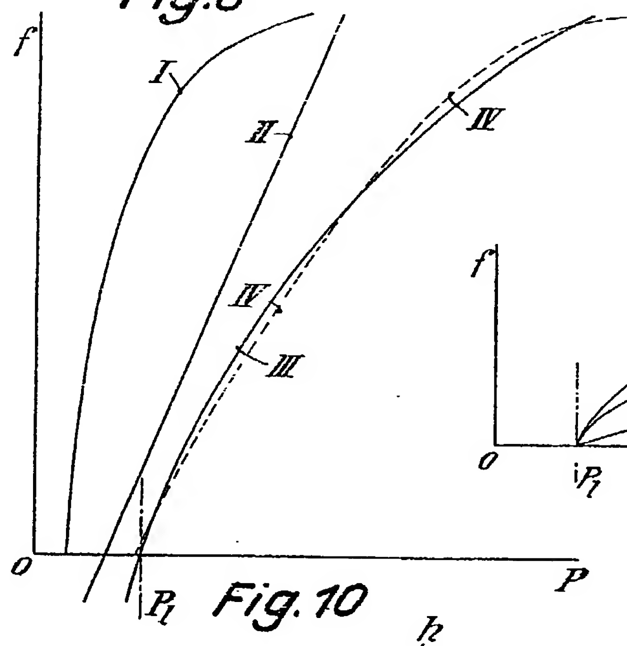


Fig.9

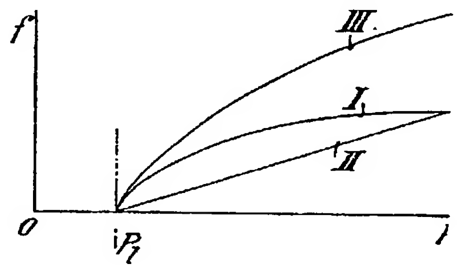


Fig.10

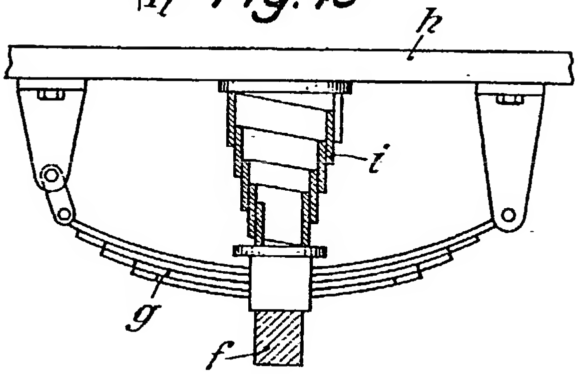


Fig.12

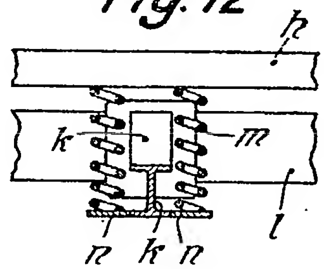


Fig.11

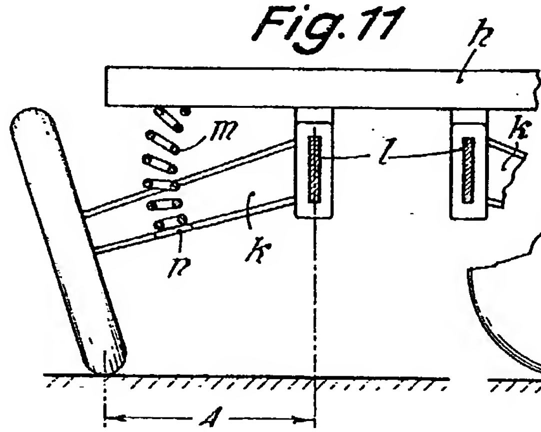


Fig.13

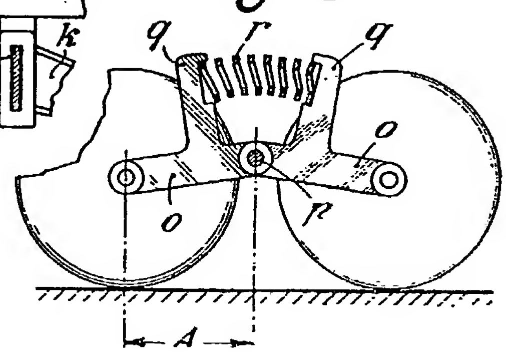


Fig. 1

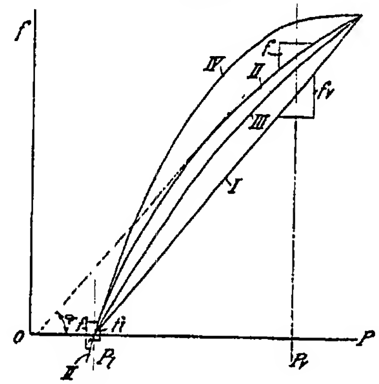


Fig. 2

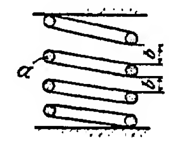


Fig. 3

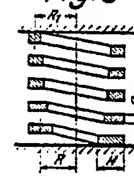


Fig. 4

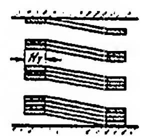


Fig. 5

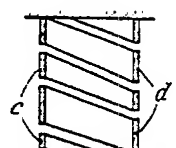


Fig. 6

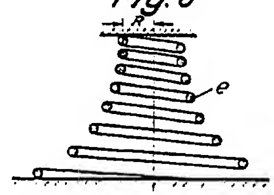


Fig. 7

Fig. 8

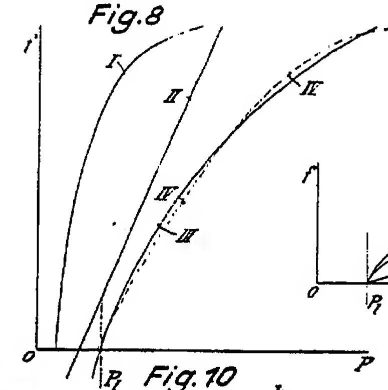


Fig. 9

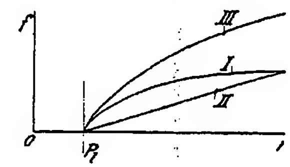


Fig. 10

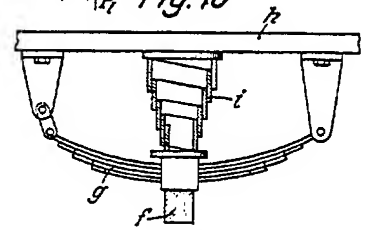


Fig. 12

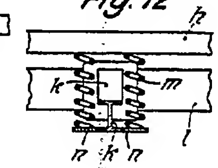


Fig. 11

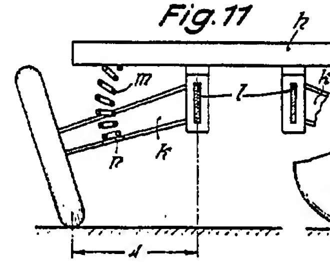
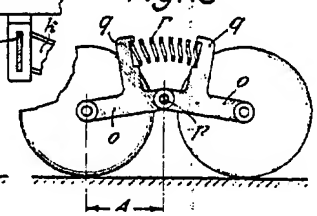


Fig. 13



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